CLAIMS

1. A magneto-resistive effect memory element, comprising:

a first ferromagnetic film;

a second ferromagnetic film;

a first nonmagnetic film provided between the first ferromagnetic film and the second ferromagnetic film;

a first conductive film for generating a magnetic field for causing magnetization inversion in at least one of the first ferromagnetic film and the second ferromagnetic film, the first conductive film not being electrically in contact with the first ferromagnetic film or the second ferromagnetic film; and

a second conductive film and a third conductive film for supplying an electric current to the first ferromagnetic film, the first nonmagnetic film, and the second ferromagnetic film,

wherein:

the first ferromagnetic film and the second ferromagnetic film have different magnetization inversion characteristics with respect to the magnetic field, and

the first nonmagnetic film contains at least a nitride.

2. A magneto-resistive effect memory element according to claim 1, wherein at least one of the first ferromagnetic film and the second ferromagnetic film contains a nitride.

3. A magneto-resistive effect memory element according to claim 2, wherein at least one of the first ferromagnetic film and the second ferromagnetic film contains a nitride which contains at least one of Fe and Co as a main component.

4. A magneto-resistive effect memory element according to claim 1, wherein at least one of the second conductive film and the third conductive film contains a nitride.

5. A magneto-resistive effect memory element according to claim 4, wherein at least one of the second conductive film and the third conductive film contains TiN.

6. A magneto-resistive effect memory element according to claim 1, wherein the first nonmagnetic film has a thickness of 0.5 nm to 4 nm.

7. A magneto-resistive effect memory element according to claim 1, wherein the first nonmagnetic film contains AlN.

8. A magneto-resistive effect memory element according to claim 1, wherein the first nonmagnetic film contains BN.

9. A magneto-resistive effect memory element according to claim 1, wherein the first nonmagnetic film contains InN.

10. A magneto-resistive effect memory element according to claim 1, wherein the first nonmagnetic film contains at least M-N-(O) where M is at least one metal element of Al, B and In, N is a nitrogen element, and (O) is an oxygen element contained in the nitride.

11. A magneto-resistive effect memory element according to claim 1, wherein the first nonmagnetic film is formed by nitriding a nonmagnetic metal material.

12. A magneto-resistive effect memory element according to claim 1, wherein the first nonmagnetic film further contains

an oxide.

13. A method for producing a magneto-resistive effect memory element, the magneto-resistive effect memory element being defined by claim 12, the method comprising:

a first step of forming the first nonmagnetic film by nitriding a nonmagnetic metal material in a nitrogen atmosphere; and

a second step of oxidizing the first nonmagnetic film in an oxygen atmosphere.

14. A method for producing a magneto-resistive effect memory element according to claim 13, wherein at least one of the first step and the second step is performed a plurality of times.

15. A method for producing a magneto-resistive effect memory element according to claim 13, further comprising:

a third step of forming the first ferromagnetic film; and

a fourth step of forming the second ferromagnetic film.

16. A magneto-resistive effect memory element according to claim 10, wherein the first nonmagnetic film mainly contains M-N, and mainly contains M-O in a grain boundary thereof.

17. A method for producing a magneto-resistive effect memory element, the magneto-resistive effect memory element being defined by claim 16, the method comprising:

a first step of forming the first nonmagnetic film by nitriding the metal element in a nitrogen atmosphere; and

a second step of oxidizing the first nonmagnetic film in an oxygen atmosphere.

18. A method for producing a magneto-resistive effect memory element according to claim 17, wherein at least one of the first step and the second step is performed a plurality of times.

19. A method for producing a magneto-resistive effect memory element according to claim 17, further comprising:

a third step of forming the first ferromagnetic film; and

a fourth step of forming the second ferromagnetic film.

20. A magneto-resistive effect memory element according to claim 10, wherein the first nonmagnetic film mainly contains M-N, and also contains M-O in a dispersed manner.

21. A method for producing a magneto-resistive effect memory element, the magneto-resistive effect memory element being defined by claim 20, the method comprising:

a first step of forming the first nonmagnetic film by nitriding the metal element in a nitrogen atmosphere; and

a second step of oxidizing the first nonmagnetic film in an oxygen atmosphere.

22. A method for producing a magneto-resistive effect memory element according to claim 21, wherein at least one of the first step and the second step is performed a plurality of times.

23. A method for producing a magneto-resistive effect memory element according to claim 21, further comprising:

a third step of forming the first ferromagnetic film; and

a fourth step of forming the second ferromagnetic film.

24. A magneto-resistive effect memory element according to claim 1, wherein the first nonmagnetic film mainly includes at least one M-N film and at least one M-O film, where M is at least one metal element of Al, B and In, N is a nitrogen element, and O is an oxygen element.

25. A method for producing a magneto-resistive effect memory element, the magneto-resistive effect memory element being defined by claim 24, the method comprising:

a first step of forming the at least one M-N film by nitriding the metal element in a nitrogen atmosphere; and

a second step of forming the at least one M-O film by oxidizing the metal element in an oxygen atmosphere.

26. A method for producing a magneto-resistive effect memory element according to claim 25, wherein at least one of the first step and the second step is performed a plurality of times.

27. A method for producing a magneto-resistive effect memory element according to claim 25, further comprising:

a third step of forming the first ferromagnetic film; and

a fourth step of forming the second ferromagnetic film.

28. An MRAM device, comprising:

a plurality of magneto-resistive effect memory elements according to claim 1,

wherein a plurality of first conductive films, a plurality of second conductive films, and a plurality of third conductive films are each located in a prescribed direction.

29. A magneto-resistive effect memory element, comprising:

a plurality of stacking structures;

at least one first nonmagnetic film provided between the plurality of stacking structures; and

a first conductive film and a second conductive film for supplying an electric current to the plurality of stacking structures,

wherein:

the plurality of stacking structures each have a first ferromagnetic film, a second ferromagnetic film, and a second nonmagnetic film provided between the first ferromagnetic film and the second ferromagnetic film,

the first ferromagnetic film and the second ferromagnetic film have different magnetization inversion characteristics with respect to a magnetic field,

the magneto-resistive effect memory element further includes a third conductive film for generating a magnetic field for causing magnetization inversion in at least one of the first ferromagnetic films and the second ferromagnetic films included in the plurality of stacking structures, the third conductive film not being electrically in contact with the first ferromagnetic films or the second ferromagnetic films, and

at least one of the second nonmagnetic films

included in the plurality of stacking structures contains at least a nitride.

30. A magneto-resistive effect memory element according to claim 29, wherein the first ferromagnetic films have different magnitudes of magnetic coersive forces.

31. A magneto-resistive effect memory element according to claim 29, wherein the second ferromagnetic films have different magnitudes of magnetic coersive forces.

32. A magneto-resistive effect memory element according to claim 29, wherein the at least one of the first ferromagnetic films and the second ferromagnetic films contains a nitride.

33. A magneto-resistive effect memory element according to claim 32, wherein at least one of the first ferromagnetic films and the second ferromagnetic films contains a nitride which contains at least one of Fe and Co as a main component.

34. A magneto-resistive effect memory element according to claim 29, wherein the at least one of the first conductive film and the second conductive film contains a nitride.

35. A magneto-resistive effect memory element according to claim 34, wherein the at least one of the first conductive film and the second conductive film contains TiN.

36. A magneto-resistive effect memory element according to claim 29, wherein at least one of the second nonmagnetic films contains at least M-N-(O) where M is at least one metal element of Al, B and In, N is a nitrogen element, and (O) is an oxygen element contained in the nitride.

37. A magneto-resistive effect memory element according to claim 29, wherein at least one of the second nonmagnetic films is formed by nitriding a nonmagnetic metal material.

38. A magneto-resistive effect memory element according to claim 29, wherein at least one of the second nonmagnetic films contains an oxide.

39. An MRAM device, comprising:

a plurality of magneto-resistive effect memory elements according to claim 29,

wherein a plurality of first conductive films, a plurality of second conductive films, and a plurality of third conductive films are each located in a prescribed direction.

40. A magneto-resistive effect element, comprising:

a first ferromagnetic film;

a second ferromagnetic film; and

a first nonmagnetic film provided between the first ferromagnetic film and the second ferromagnetic film,

wherein:

the first ferromagnetic film and the second ferromagnetic film have different magnetization inversion characteristics with respect to a magnetic field, and

the first nonmagnetic film contains at least a nitride.

41. A magneto-resistive effect element according to claim 40, wherein at least one of the first ferromagnetic film and the second ferromagnetic film contains a nitride.

42. A magneto-resistive effect element according to claim 41, wherein at least one of the first ferromagnetic film and the second ferromagnetic film contains a nitride which contains at least one of Fe and Co as a main component.

43. A magneto-resistive effect element according to claim 40, wherein the first nonmagnetic film has a thickness of 0.5 nm to 4 nm.

44. A magneto-resistive effect element according to claim 40, wherein the first nonmagnetic film contains AlN.

45. A magneto-resistive effect element according to claim 40, wherein the first nonmagnetic film contains BN.

46. A magneto-resistive effect element according to claim 40, wherein the first nonmagnetic film contains InN.

47. A magneto-resistive effect element according to claim 40, wherein the first nonmagnetic film contains at least M-N-(O) where M is at least one metal element of Al, B and In, N is a nitrogen element, and (O) is an oxygen element contained in the nitride.

48. A magneto-resistive effect element according to claim 40, wherein the first nonmagnetic film is formed by nitriding a nonmagnetic metal material.

49. A magneto-resistive effect element according to claim 40, wherein the first nonmagnetic film further contains an oxide.

50. A method for producing a magneto-resistive effect

element, the magneto-resistive effect element being defined by claim 49, the method comprising:

a first step of forming the first nonmagnetic film by nitriding a nonmagnetic metal material in a nitrogen atmosphere; and

a second step of oxidizing the first nonmagnetic film in an oxygen atmosphere.

51. A method for producing a magneto-resistive effect element according to claim 50, wherein at least one of the first step and the second step is performed a plurality of times.

52. A method for producing a magneto-resistive effect element according to claim 50, further comprising:

a third step of forming the first ferromagnetic film; and

a fourth step of forming the second ferromagnetic film.

53. A magneto-resistive effect element according to claim 47, wherein the first nonmagnetic film mainly contains M-N, and mainly contains M-O in a grain boundary thereof.

54. A method for producing a magneto-resistive effect element, the magneto-resistive effect element being defined by claim 53, the method comprising:

a first step of forming the first nonmagnetic film by nitriding the metal element in a nitrogen atmosphere; and

a second step of oxidizing the first nonmagnetic film in an oxygen atmosphere.

55. A method for producing a magneto-resistive effect element according to claim 54, wherein at least one of the first step and the second step is performed a plurality of times.

56. A method for producing a magneto-resistive effect element according to claim 54, further comprising:

a third step of forming the first ferromagnetic film; and

a fourth step of forming the second ferromagnetic film.

57. A magneto-resistive effect element according to claim 47, wherein the first nonmagnetic film mainly contains M-N, and also contains M-O in a dispersed manner.

58. A method for producing a magneto-resistive effect element, the magneto-resistive effect element being defined by claim 57, the method comprising:

a first step of forming the first nonmagnetic film by nitriding the metal element in a nitrogen atmosphere; and

a second step of oxidizing the first nonmagnetic film in an oxygen atmosphere.

59. A method for producing a magneto-resistive effect element according to claim 58, wherein at least one of the first step and the second step is performed a plurality of times.

60. A method for producing a magneto-resistive effect element according to claim 58, further comprising:

a third step of forming the first ferromagnetic

film; and

a fourth step of forming the second ferromagnetic film.

61. A magneto-resistive effect element according to claim 40, wherein the first nonmagnetic film mainly includes at least one M-N film and at least one M-O film, where M is at least one metal element of Al, B and In, N is a nitrogen element, and O is an oxygen element.

62. A method for producing a magneto-resistive effect element, the magneto-resistive effect element being defined by claim 61, the method comprising:

a first step of forming the at least one M-N film by nitriding the metal element in a nitrogen atmosphere; and

a second step of forming the at least one M-O film by oxidizing the metal element in an oxygen atmosphere.

63. A method for producing a magneto-resistive effect element according to claim 62, wherein at least one of the first step and the second step is performed a plurality of times.

64. A method for producing a magneto-resistive effect element according to claim 62, further comprising:

a third step of forming the first ferromagnetic film; and

a fourth step of forming the second ferromagnetic film.

65. A method for producing a metal insulating film containing at least a nitride, the method comprising:

a first step of forming the nitride by nitriding a prescribed metal material in a nitrogen atmosphere; and

a second step of oxidizing the nitride in an oxygen atmosphere.

66. A method for producing a metal insulating film according to claim 65, wherein the prescribed metal material is at least one of Al, B and In.

67. A method for producing a metal insulating film according to claim 65, wherein at least one of the first step and the second step is performed a plurality of times.

68. A method for producing a metal insulating film including at least one M-N film and at least one M-O film where M is a prescribed metal element, N is a nitrogen element, and O is an oxygen element, the method comprising:

a first step of forming the at least one M-N film by nitriding the metal element in a nitrogen atmosphere; and

a second step of forming the at least one M-O film by oxidizing the metal element in an oxygen atmosphere.

69. A method for producing a metal insulating film according to claim 68, wherein the prescribed metal element is at least one of Al, B and In.

70. A method for producing a metal insulating film according to claim 68, wherein at least one of the first step and the second step is performed a plurality of times.

71. (Added) A metal insulating film mainly comprising M-N and mainly comprising M-O in a grain boundary thereof, where

M is a prescribed metal element, N is a nitrogen element, and O is an oxygen element.

72. (Added) A metal insulating film mainly comprising M-N and comprising M-O in a dispersed manner, where M is a prescribed metal element, N is a nitrogen element, and O is an oxygen element.

73. (Added) A metal insulating film comprising at least one M-N film and at least one M-O film, where M is at least one metal element of Al, B and In, N is a nitrogen element, and O is an oxygen element.

74. (Added) A metal insulating film comprising two or more layers each including at least one M-N film and at least one M-O film, where M is at least one metal element of Al, B and In, N is a nitrogen element, and O is an oxygen element, wherein the two or more layers are stacked so that the at least one M-N film and the at least one M-O film are stacked alternately.

75. (Added) A method for producing a metal insulating film provided between a first ferromagnetic film and a second ferromagnetic film, the metal insulating film containing at least a nitride, the method comprising:

a first step of forming the nitride by nitriding a prescribed metal material in a nitrogen atmosphere; and

a second step of oxidizing the nitride in an oxygen atmosphere.

76. (Added) A method for producing a metal insulating film provided between a first ferromagnetic film and a second ferromagnetic film, the metal insulating film containing

at least one M-N film and at least one M-O film, where M is a prescribed metal element, N is a nitrogen element, and O is an oxygen element, the method comprising:

a first step of forming the at least one M-N film by nitriding the metal element in a nitrogen atmosphere; and

a second step of forming the at least one M-O film by oxidizing the metal element in an oxygen atmosphere.